Section 5 Water Supply and Use

5.1 Introduction 5-1

5.2 Background 5-1

5.3 Water Supply 5-2
5.3.1 Surface Water Supply 5-2
5.3.2 Groundwater Supply 5-16

5.4 Water Resources Definitions 5-17
5.4.1 Water Use Terms 5-17
5.4.2 Water Supply Terms 5-19
5.4.3 Other Water Terms 5-20

5.5 Water Use 5-20
5.5.1 Municipal and Industrial Water Use 5-20
5.5.2 Secondary Systems Water Use 5-23
5.5.3 Agricultural Water Use 5-23
5.5.4 Wetland and Riparian Water Use 5-25
5.5.5 Instream Flow Requirements 5-26

5.6 Interbasin Diversions 5-26

5.7 Water Quality 5-26

5.8 References 5-27

Tables

5-1 Monthly Streamflow Probabilities of Occurrence, Virgin River at Virgin 5-9
5-2 Monthly Streamflow Probabilities of Occurrence of Kanab Creek near Kanab 5-9
5-3 Mean Monthly and Annual Streamflows 5-10
5-4 Peak Flows for the Virgin River at Virgin 5-12
5-5 Flood Frequency for the Virgin River near Virgin 5-13
5-6 Peak Flows for Kanab Creek near Kanab 5-13
5-7 Flood Frequency for Kanab Creek near Kanab 5-16
5-8 Culinary Water Diverted Per Capita Day 5-22
5-9 Estimated Current Culinary Water Use 5-23
5-10 Estimated Current Secondary Water Use 5-24
5-11 Existing Irrigation Water Storage Reservoirs 5-24
5-12 Estimated Current Irrigation Water Use 5-25

Figures

5-1 Virgin River System-Utah, Stream Flow and Depletion Chart 5-3
5-2 Virgin River Simulated Quail Creek Project 5-4
5-3 Kanab Creek and Johnson Wash Stream Flow and Stream Depletion Chart 5-5
5-4 Annual Flows, Virgin River at Virgin 5-6
5-5 Monthly Mean Flows, Virgin River at Virgin 5-7
5-6 Monthly Streamflow Probabilities, Virgin River at Virgin 5-14
5-7 Monthly Streamflow Probabilities, Kanab Creek near Kanab 5-15

5 Water Supply and Use

5.1 Introduction

This section discusses the present water supply and use. As some of the tributary drainages are outside Utah, it is necessary to define the hydrologic yield of the total area above the state line to properly understand the water resources. This includes surface water and groundwater supplies and use.

The rapidly increasing population has and will continue to demand more water. Expanding development of light industry and recreational facilities will also add to the water supply demand.

5.2 Background

The water supply in the basin is influenced by storm paths and topography. Storms from the Pacific Ocean produce the largest amounts of precipitation, mostly in the form of snow.

The base period for determining the water supply is water years 1941 through 1990. This 50-year period will be used for discussing surface water. Groundwater is discussed using various time periods. Discharge and recharge data vary depending on the time frame of studies and investigations.

Most of the water supply in the Kanab Creek/Virgin River Basin originates as precipitation on the surface hydrologic drainage within Utah. A small portion of the water supply comes as inflow from Nevada in the Beaver Dam Wash and from Arizona in the Fort Pierce Wash. Groundwater transbasin inflow from the Markagunt Plateau (Navajo Lake area) surfaces in the Virgin River drainage. The same is true of the Paunsaugunt Plateau (Bryce Canyon area) above Kanab Creek and Johnson Wash.

The largest water producing area is around the headwaters of the North Fork of the Virgin River and its tributaries. Other high and moderate producing areas include the Pine Valley Mountains, Paunsaugunt

Plateau and the Cougar Mountains in the upper Beaver Dam Wash drainage.

Many areas yield high volume-short duration flood flows produced by high intensity cloudburst storms. Most of these occur in lower elevation areas such as Johnson Wash, Fort Pierce Wash, Kanab Creek and lower Beaver Dam Wash. Rain on snow and early spring sustained high temperatures also occasionally produce high flows. These are generally longer duration snow-melt occurrences.

Water was being diverted by the Indians for irrigation when early explorations were conducted prior to establishment of the first white settlements. With the arrival of the white settlers in the 1850s, diversion of water for irrigation was top priority.

The first diversions and irrigation works were simple to build, but soon floods raised havoc with these systems. Stream channels deepened and banks eroded until they were often many times larger. Part of this occurred as a result of natural geologic processes and part was man-caused from overuse and abuse of the watersheds.

5.3 Water Supply

Water from melting snow makes up the largest percentage of streamflow and causes the high flows during the spring. The balance of the snowpack infiltrates into the ground and what is not used to support vegetation is the source for springs and groundwater recharge. Warm season rainstorms help augment streamflows.

5.3.1 Surface Water Supply

Most of the surface water comes from snow-melt during the months of March, April and May. Figure 5-1 is a graphical representation of the average annual streamflows and stream depletions for the period 1941-1990 for the Virgin River. The width of the flow line indicates the volume. Simulated river flows and diversions resulting from full use of the Quail Creek project are shown in Figure 5-2. By comparison, the flows in Kanab Creek and Johnson Wash are much smaller. These are shown in Figure 5-3. The volumes are derived from computed water budgets and from actual, correlated and estimated stream gage records.

One of the long-term U. S. Geological Survey (USGS) stream gages in the basin is located on the Virgin River near the town of Virgin (USGS gage 09406000). The Virgin gage has a period of record of 1909-1971, and then 1979 to the present. The missing years of daily flows for 1972 to 1978 have been estimated using a computer simulation and the daily flow record at the Hurricane gage. This provides a long-term water supply record at Virgin for the 1910 to 1991 period.

This gage is important because it has a long period of record, is located on the main stem of the river below many of the major tributaries, and is upstream from several major diversions. For these reasons, this gaging station is very useful in estimating and correlating streamflow records in other areas of the basin that are not gaged or have been gaged for a shorter time.

Figure 5-4 is a bar chart of the annual runoff at the Virgin gage for an 81-year period extending back to 1910. The highest year was 1922 with 337,000 acre-feet, and the lowest years were 1977 and 1990 with 69,000 acre-feet. Figure 5-5 shows the average monthly flows for the Virgin gage for the 1941 to 1990 50-year period. This

FIGURE 5-1
Virgin River System - Utah
Streamflow and Stream Depletion Chart (1941-1990 Base Period)

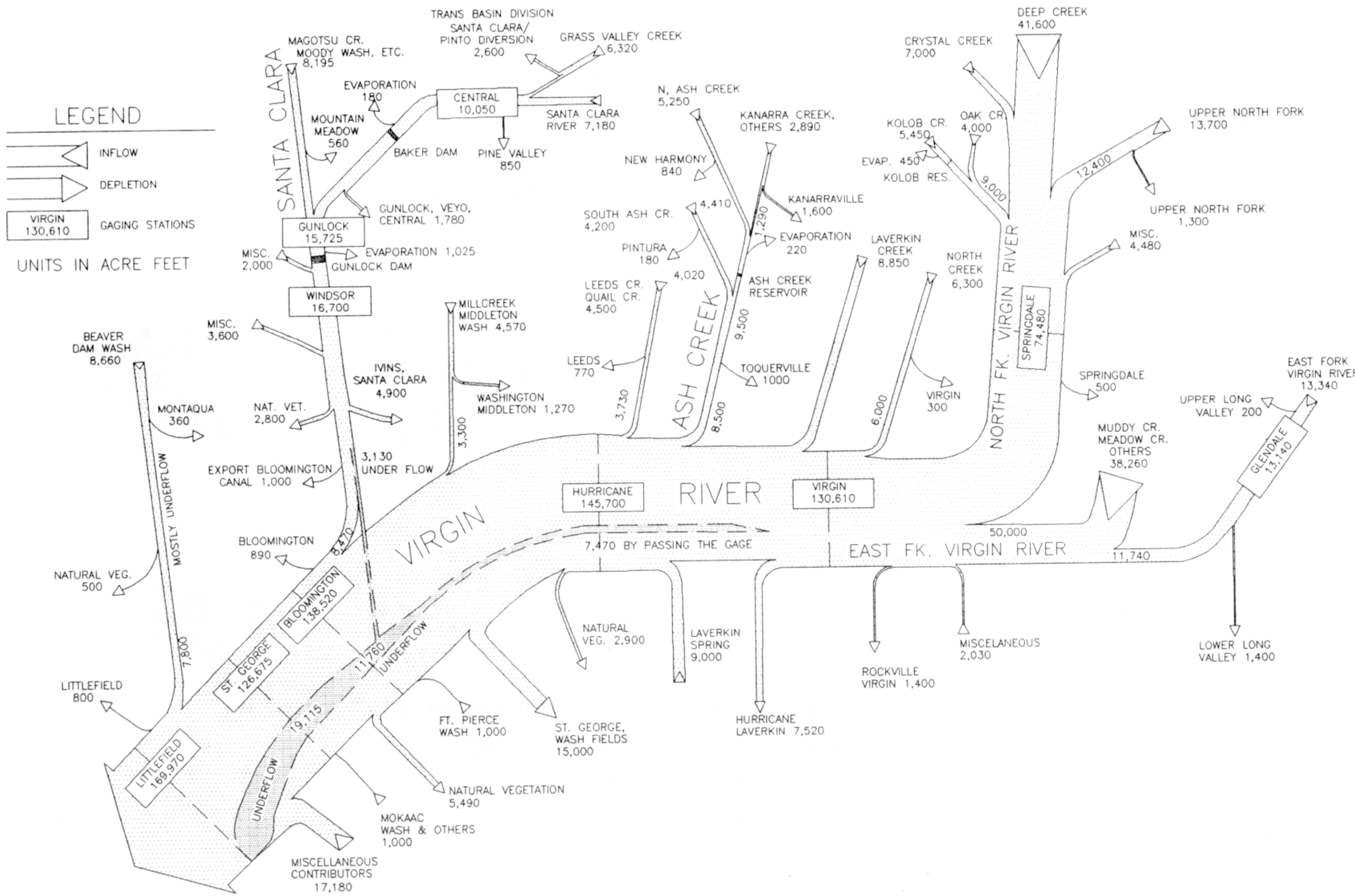


FIGURE 5-2
Virgin River
Simulated Quail Creek Project
Virgin Gage to Hurricane Gage (1941-1990 Base Period in Acre-feet)

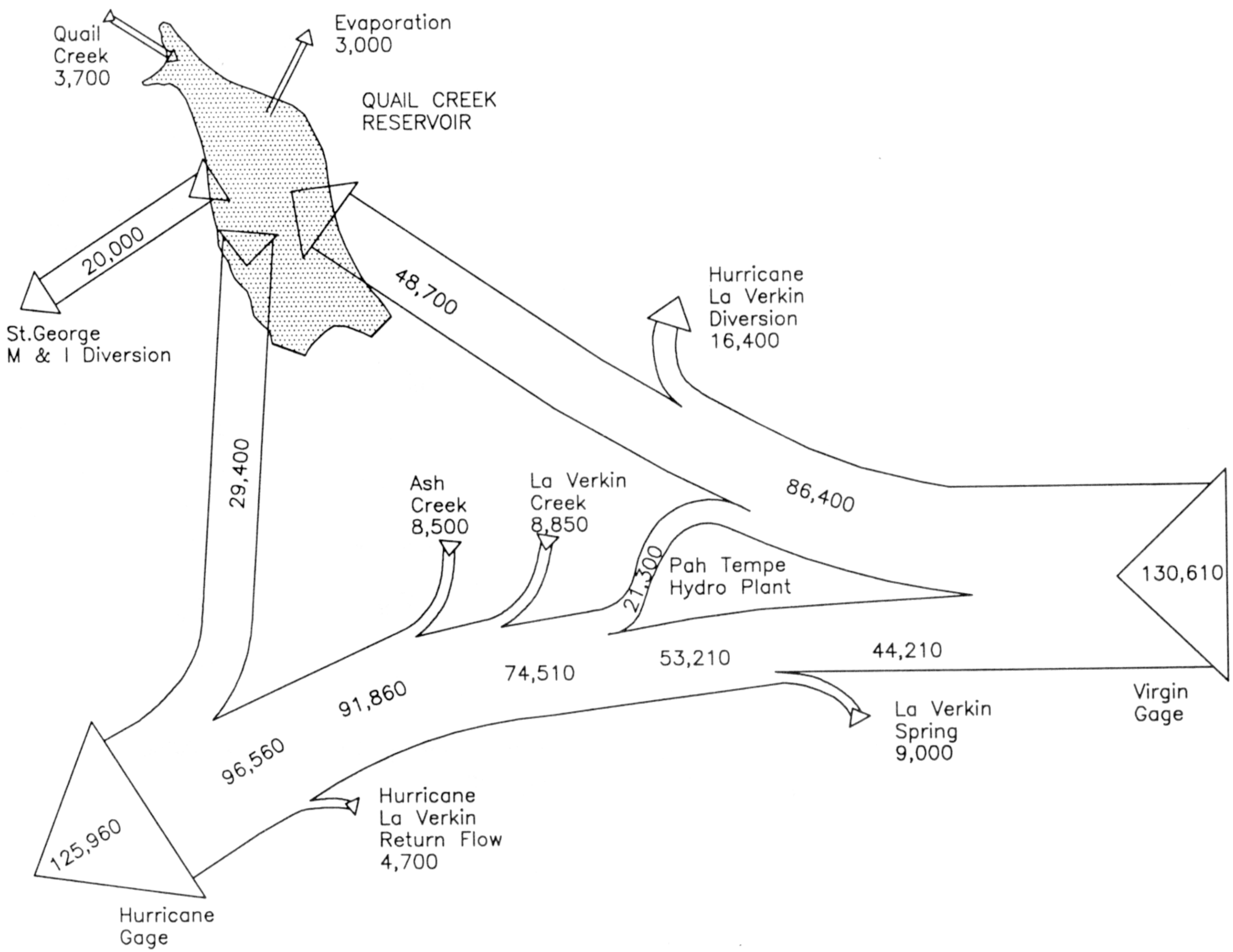


FIGURE 5-3
Kanab Creek and Johnson Wash
Streamflow and Stream Depletion Chart (1941-1990 Base Period)

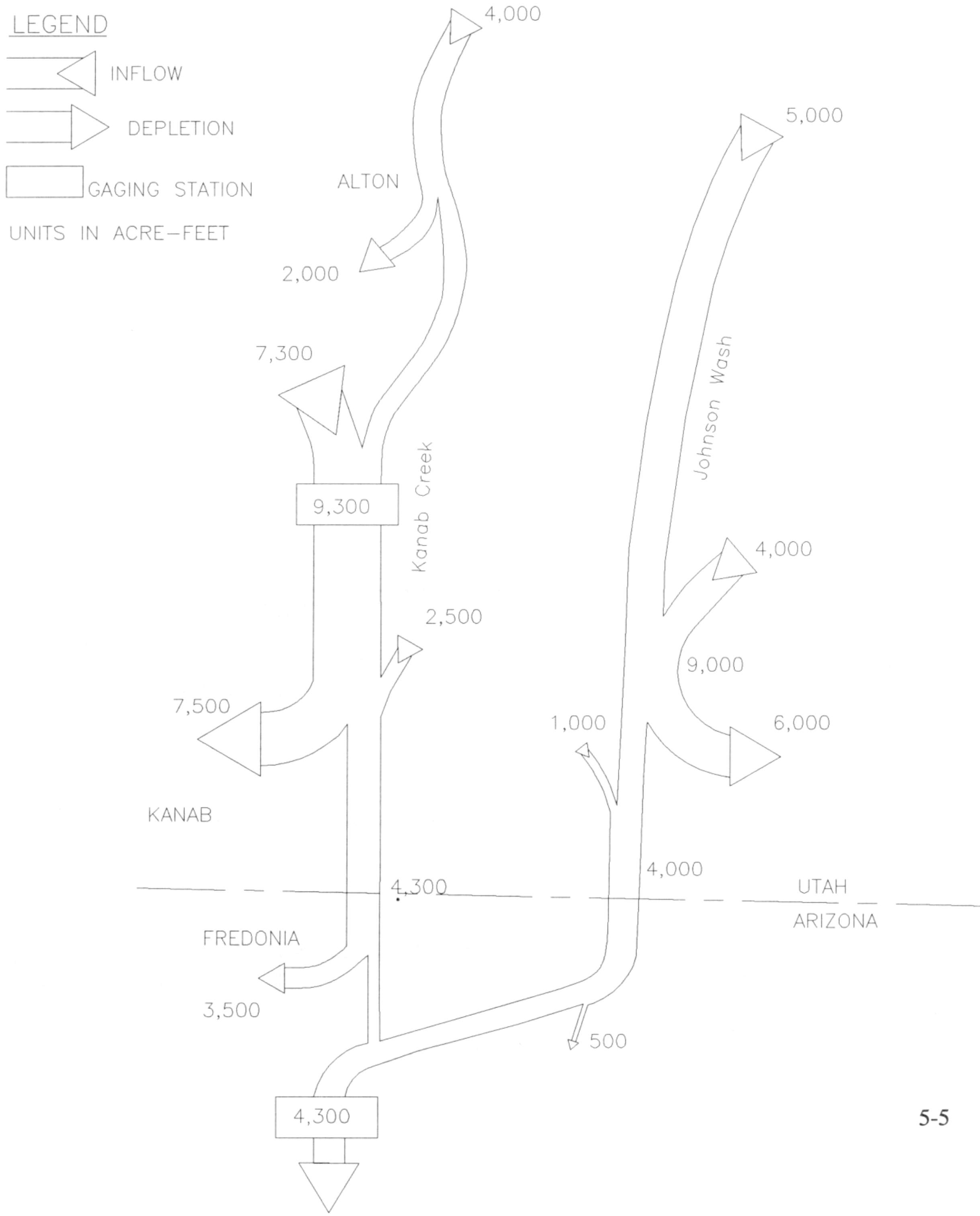


FIGURE 5-4
Annual Flows, Virgin River at Virgin

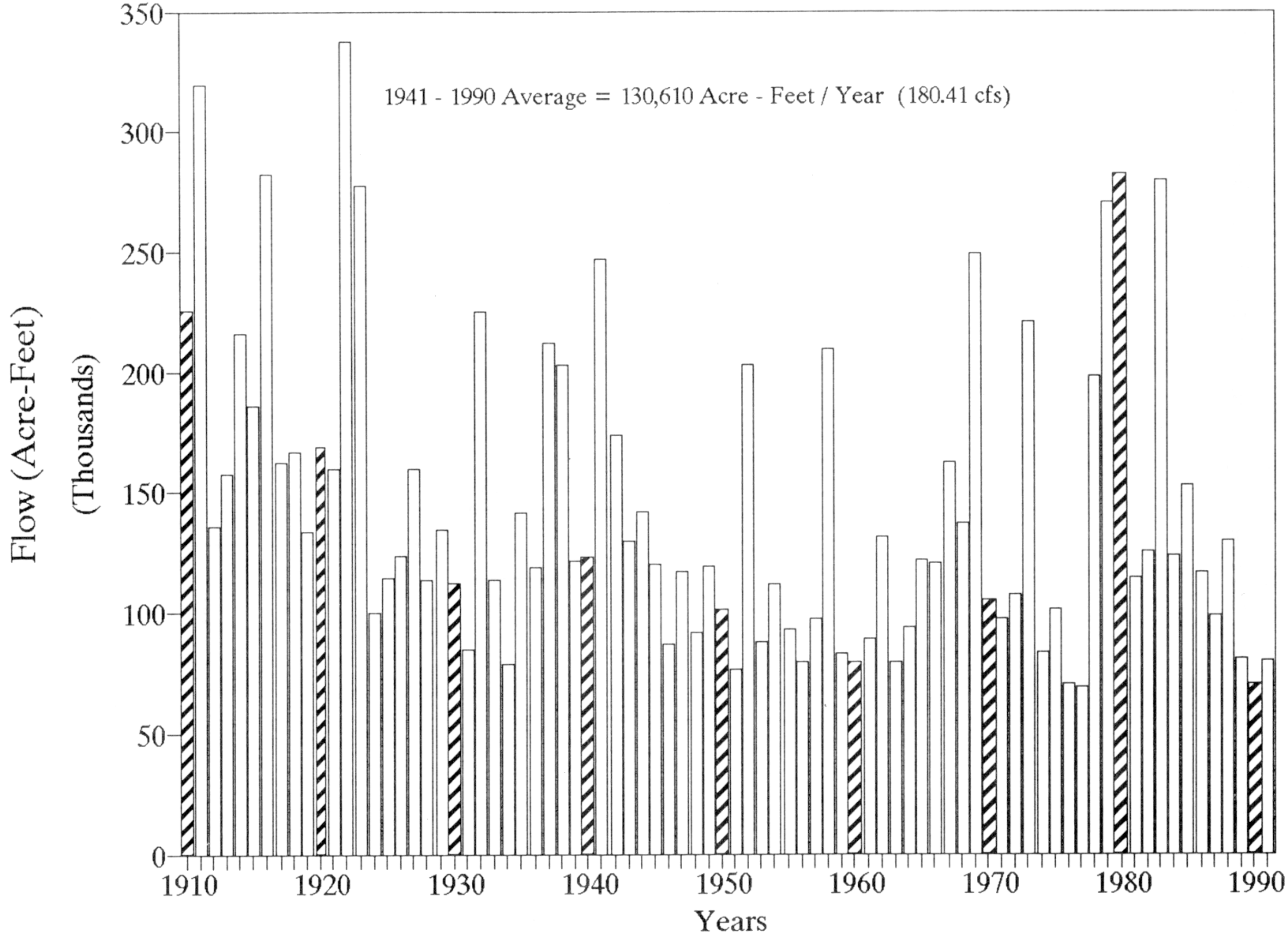
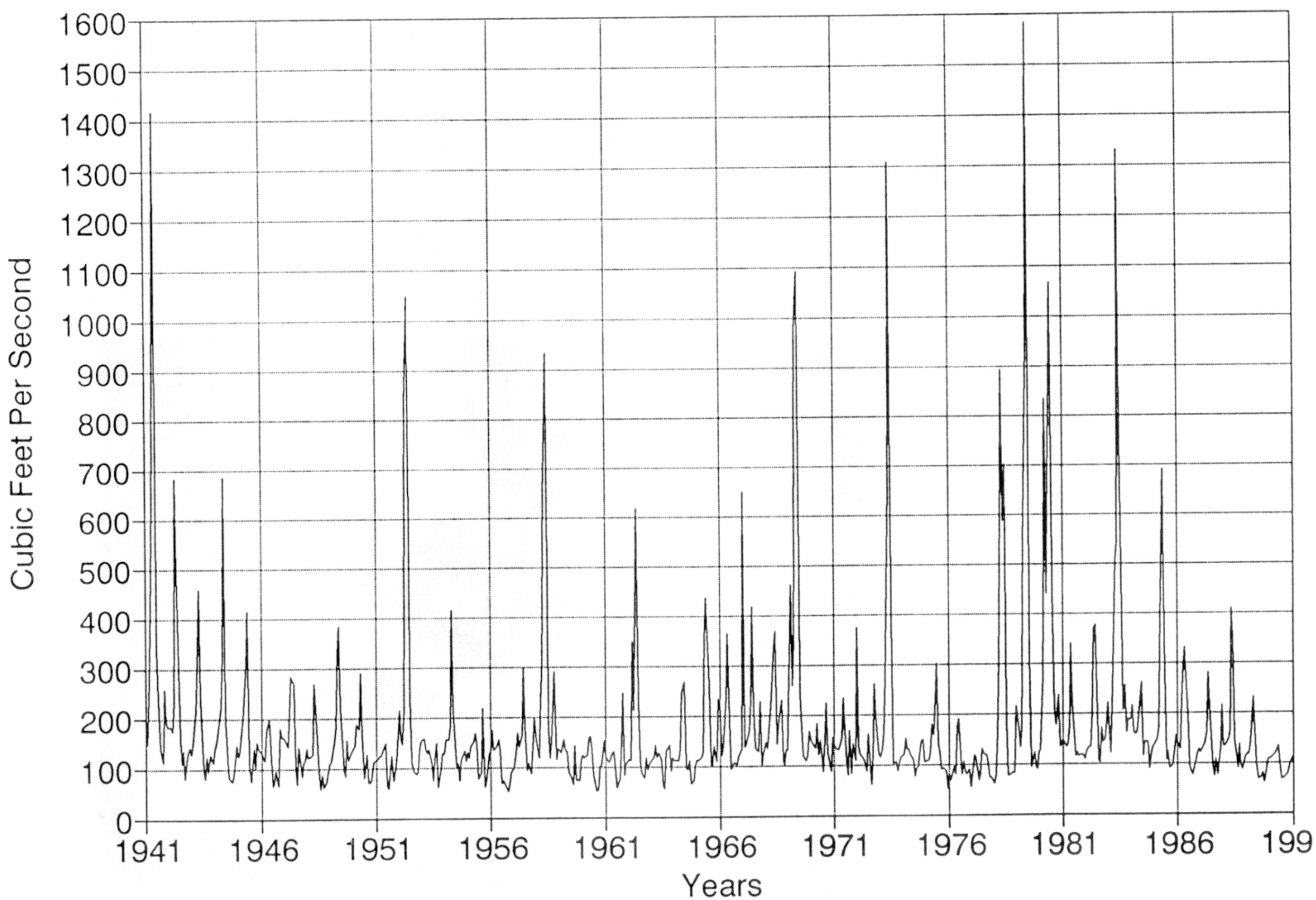


FIGURE 5-5
Monthly Mean Flows, Virgin River at Virgin

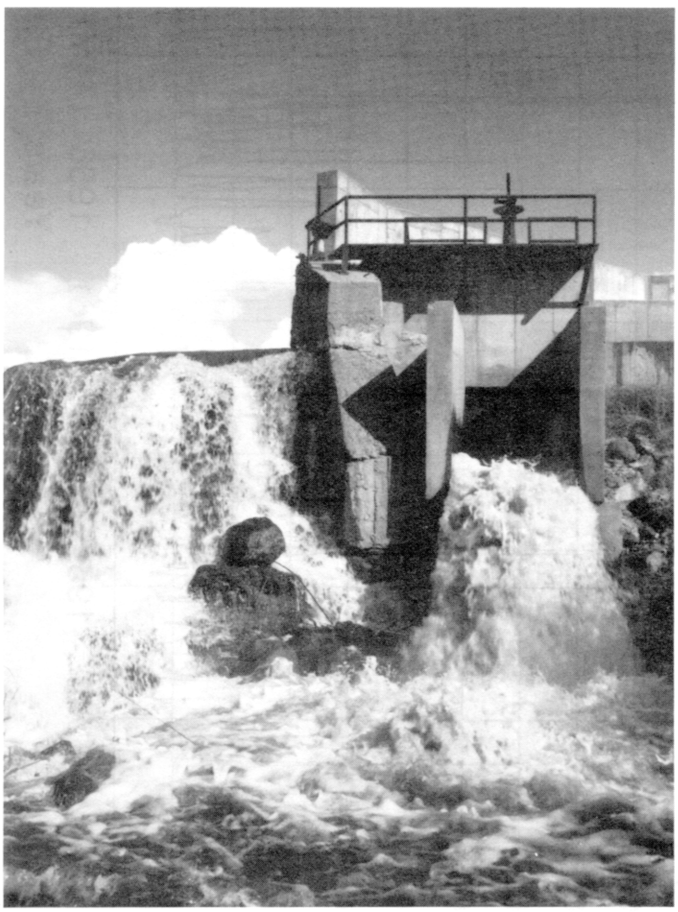


hydrograph shows the high variation of the flow of the Virgin River.

The flows at the Virgin gage at different probability levels are shown in Table 5-1. Similar data are shown for Kanab Creek in Table 5-2.

A probability level of 90 percent means nine times in 10 the flows will be greater than the values shown. A level of 50 percent means near average conditions. The numbers are based on a log normal frequency analysis of monthly streamflows at the Virgin gage for water years 1910 through 1971, and also 1979 through 1990. Figure 5-6 shows this graphically. Figure 5-7 shows these data for Kanab Creek near Kanab.

Table 5-3 lists the stream gages in the Kanab Creek/Virgin River Basin. The station number, period of record and description are shown along with the mean monthly and annual flows in acre-feet. The values in this table are computed from rounded summary data; therefore, the values will be slightly different than if they had been computed from the actual daily flow records.



Most of the basin is prone to flash flooding from rainfall. The instantaneous peak flows from these flash floods can be very high and cause extreme erosion and property damage. For example, the highest peak flow ever recorded at the Virgin gage was 22,800 cubic feet per second (cfs) on December 6, 1966. As a comparison, the 50 percent probability flow in the month of May from Table 5-1 for the Virgin gage is 333 cfs. The peak flows during the spring are generally a result of snowmelt runoff. Late summer instantaneous peaks come from cloudburst floods. The highest peak flow for each year at the Virgin gage with the dates of occurrence is shown in Table 5-4. Flood frequencies at the Virgin gage are given in Table 5-5. Also refer to Figures 5-6 and 5-7.

The peak flow at the Kanab Creek gage for the period of record was 3,030 cfs on September 8,

TABLE 5-1
MONTHLY STREAMFLOW PROBABILITIES OF OCCURRENCE, VIRGIN RIVER AT VIRGIN, 1910-1971 AND 1979-1990.

Month	90%	80%	50% (acre-feet)	20%	10%
January	6783	7189	7933	9236	9902
February	5867	6520	7332	9676	13215
March	7802	8265	11322	18478	26297
April	7616	9046	17027	36444	40212
May	6802	8291	14881	43156	68799
June	3897	4576	6218	12378	19276
July	4090	4591	5864	7901	10926
August	4776	5206	7225	9275	11191
September	3719	4332	5390	8300	13298
October	4722	5339	6600	8373	9531
November	6046	6286	7378	9105	11632
December	6784	7205	8195	10105	13172
Annual	56954	68429	94174	151309	228897

TABLE 5-2
MONTHLY STREAMFLOW PROBABILITIES OF OCCURRENCE OF KANAB CREEK NEAR KANAB, 1979-1990.

Month	90%	80%	50%	20%	10%
January	571	782	878	992	1020
February	666	717	760	1598	2296
March	676	784	1327	2939	4261
April	586	672	906	3597	7044
May	480	533	639	841	1565
June	354	377	453	552	690
July	325	378	490	608	820
August	416	497	635	740	978
September	375	441	536	927	1015
October	406	477	742	1053	1508
November	403	471	724	847	895
December	389	638	893	1144	1337
Annual	4691	5538	8557	12112	15927

TABLE 5-3
MEAN MONTHLY AND ANNUAL STREAMFLOWS IN ACRE-FEET

Number	Description	Years	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
09404450	East Fork Virgin River near Glendale	1967-90	879	969	1075	1082	1113	1502	2385	2064	973	784	764	705	14295
09405200	Deep Creek near Cedar City	1987-90	83	102	93	84	83	169	260	216	103	60	73	51	1377
09405250	East Fork Deep Creek near Cedar City	1987-90	143	221	169	167	150	247	467	372	153	73	77	65	2303
09405300	Crystal Creek near Cedar City	1957-61	71	76	68	77	68	112	663	3044	671	115	122	146	5233
09405400	North Fork Virgin River near Glendale	1973-78	255	257	219	181	187	283	350	558	544	352	287	240	3712
09405420	North Fork Virgin River below Bulloch Canyon near Glendale	1975-84	794	773	769	801	1046	1384	2139	2479	1433	1007	942	739	14306
09405450	North Fork Virgin River above Zion Narrows near Glendale	1979-84	1001	1000	1022	1005	1391	1758	2938	3440	1805	1192	1177	818	18546
09405499	Springdale Canal near Springdale	1969-88	409	299	275	291	216	276	471	531	575	522	476	471	4812
09405500	North Fork Virgin River near Springdale	1926-90	3492	3394	3677	3516	4175	5775	13593	18975	6728	3973	3857	3555	74712
09405900	North Creek near Virgin	1985-90	233	475	378	353	604	941	1097	246	64	155	178	115	4838
09406000	Virgin River at Virgin	1909-72 1979-90	8150	8797	10012	9962	10565	15221	23326	26773	9458	7603	8692	8510	145710
09406150	La Verkin Creek near La Verkin	1985-90	405	456	414	463	630	1009	1442	732	379	245	428	216	6817
09406300	Kanarra Creek at Kanarraville	1960-82	141	130	138	146	136	189	403	831	341	201	197	155	3008
09406500	Ash Creek near New Harmony	1939-47	635	506	318	240	570	1275	1715	1414	174	69	127	171	7051
09406700	South Ash Creek below Mill Creek near Pintura	1967-82	135	133	251	223	273	546	929	1097	658	380	233	142	4998
09407000	Ash Creek above Toquerville	1985-90	4	87	56	18	166	251	454	208	37	11	76	7	1351
09407200	Ash Creek below West Field Ditch at Toquerville	1973-82	785	843	830	826	1439	2368	2931	3539	1641	1067	916	846	18030
09407201	Ash Creek below below Diversion Dam, at Toquerville	1973-82	833	852	858	864	1510	2370	2923	3561	1658	1061	912	841	17901

TABLE 5-3 (continued)

Number	Description	Years	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
09407600	Ash Creek near Toquerville	1956-58	306	432	575	370	976	2074	4073	3209	574	491	308	360	9284
09407800	Ash Creek near La Verkin	1956-58	193	395	495	356	946	2042	3107	2707	307	263	119	316	11242
09408000	Leeds Creek near Leeds	1965-90	243	245	304	273	369	538	534	639	789	645	446	275	5300
09408150	Virgin River near Hurricane	1967-88	7562	9233	12914	13486	14114	20690	25625	32431	12365	7342	8211	7720	166107
09408175	St George-Washington Canal near Washington	1988-90	3656	3103	2451	1015	1623	2892	4295	4393	4147	4276	4493	4900	41245
09408195	Fort Pierce Wash near St George	1985-89	32	6	2	2	2	2	5	6	21	28	70	9	186
09408400	Santa Clara River near Pine Valley	1960-90	223	241	251	174	182	359	1022	2080	1479	615	354	231	7212
09408500	Santa Clara-Pinto Diversion near Pinto	1954-90	32	59	12	6	16	151	824	1101	381	11	23	0	2616
09409000	Santa Clara River near Central	1909-61	795	670	643	681	653	1149	1652	2790	1523	721	593	497	12207
09409500	Moody Wash near Veyo	1955-69	5	42	276	138	347	484	519	115	35	5	26	35	1903
09409880	Santa Clara River at Gunlock	1970-90	711	932	964	1037	2061	2633	2433	2731	1937	702	598	502	17241
09410000	Santa Clara River above Winsor Dam near Santa Clara	1943-71	780	933	1382	1081	1265	1906	2291	2014	1291	803	808	669	15224
09410100	Santa Clara River below Winsor Dam near Santa Clara	1972-90	231	405	242	807	1970	2661	2785	2552	2186	1087	942	682	16516
09410400	Santa Clara River near Santa Clara	1966-74	338	491	1568	1427	1208	1441	1980	2509	1910	725	739	723	15059
09413000	Santa Clara River at St George	1951-90	177	293	419	442	330	689	1031	553	249	228	476	189	5075
09413200	Virgin River near Bloomington	1978-90	7948	10795	11959	16365	18907	25116	28437	33957	12474	6271	7389	6071	185691
09413500	Virgin River near St George	1951-57	2831	6405	9280	10795	7940	9435	18280	14900	2045	4108	10535	1738	86896
09415000	Virgin River at Littlefield, AZ	1930-90	8990	11414	14047	14231	17566	21194	24402	25858	8063	6632	11486	8843	172726
09403600	Kanab Creek near Kanab, Utah	1979-90	775	682	847	832	1118	1647	1883	702	456	478	607	599	10625
09403780	Kanab Creek near Fredonia, AZ	1964-80	109	132	448	363	558	1027	1252	44	3	214	470	287	4907

Note: Streamflows were computed from summary values for the period of record.

TABLE 5-4
PEAK FLOWS FOR THE VIRGIN RIVER AT VIRGIN
1910-1971 AND 1979-1990

Water Year	Date	Discharge (cfs)	Water Year	Date	Discharge (cfs)
1910	01-01-10	2,770	1947	10-29-46	2,080
1911	09-10-11	10,600	1948	09-16-48	1,400
1912	07-31-12	5,100	1949	09-08-49	1,010
1913	10-27-12	12,000	1950	07-08-50	6,620
1914	07-10-14	2,500	1951	08-29-51	2,800
1915	09-03-15	4,360	1952	12-30-51	4,840
1916	07-26-16	4,350	1953	08-01-53	12,900
1917	10-06-16	2,610	1954	09-12-54	4,690
1918	03-12-18	5,100	1955	08-25-55	10,600
1919	09-03-19	1,240	1956	01-27-56	2,260
1920	08-19-20	11,000	1957	06-10-57	1,430
1921	08-22-21	12,650	1958	09-03-58	7,410
1922	08-31-22	3,400	1959	08-03-59	4,420
1923	07-22-23	5,100	1960	09-01-60	2,190
1924	09-10-24	3,100	1961	09-17-61	13,500
1925	08-25-25	1,660	1962	02-12-62	3,100
1926	10-05-25	2,770	1963	09-18-63	4,550
1927	09-13-27	4,300	1964	08-12-64	4,630
1928	10-31-27	2,600	1965	09-05-65	6,890
1929	07-31-29	4,200	1966	11-23-65	3,930
1930	08-04-30	3,000	1967	12-06-66	22,800
1931	11-17-30	3,550	1968	08-07-68	6,840
1932	02-09-32	9,000	1969	01-25-69	13,660
1933	09-08-33	2,350	1970	08-18-70	2,660
1934	07-28-34	1,550	1971	08-21-71	2,880
1935	04-08-35	1,760	1979	03-28-79	7,600
1936	07-31-36	6,300	1980	09-10-80	10,830
1937	05-08-37	1,920	1981	07-15-81	3,650
1938	03-03-38	13,500	1982	08-23-82	9,700
1939	09-06-39	10,000	1983	11-30-82	4,740
1940	09-17-40	4,370	1984	09-10-84	4,580
1941	05-06-41	2,980	1985	07-19-85	2,920
1942	10-13-42	3,150	1986	03-08-86	1,620
1943	03-09-43	920	1987	07-20-87	7,200
1944	05-12-44	1,070	1988	11-05-88	2,690
1945	05-03-45	840	1989	07-28-89	1,500
1946	08-12-46	1,700	1990	08-15-90	3,200

Note: Values are for water years.

TABLE 5-5
FLOOD FREQUENCY FOR THE VIRGIN RIVER NEAR VIRGIN
1910-1971 AND 1979-1990

Return Period	Probability[a]	Value (cfs)
2 Years	50	3898.2
5 Years	20	7306.3
10 Years	10	10145.6
25 Years	4	14396.3
50 Years	2	18048.2
100 Years	1	22109.1
200 Years	0.5	26642.9
500 Years	0.2	33376.5

[a]Computed by Log Normal Distribution

TABLE 5-6
PEAK FLOWS FOR KANAB CREEK NEAR KANAB
1960-1968 AND 1979-1990

Water Year	Date	Discharge (cfs)	Water Year	Date	Discharge (cfs)
1960	09-06-60	2100	1981	07-16-81	200
1961	09-08-61	3030	1982	09-14-82	327
1962	02-12-62	1400	1983	03-12-83	148
1963	08-31-63	1310	1984	09-20-84	1130
1964	08-12-64	600	1985	07-19-85	376
1965	03-13-65	640	1986	02-19-86	350
1966	08-02-66	360	1987	10-11-86	55
1967	12-06-66	1230	1988	08-01-88	511
1968	07-07-68	1300	1989	09-08-89	340
1979	03-28-79	190	1990	02-03-90	49
1980	04-06-80	1060			

FIGURE 5-6
Monthly Streamflow Probabilities.
Virgin River at Virgin

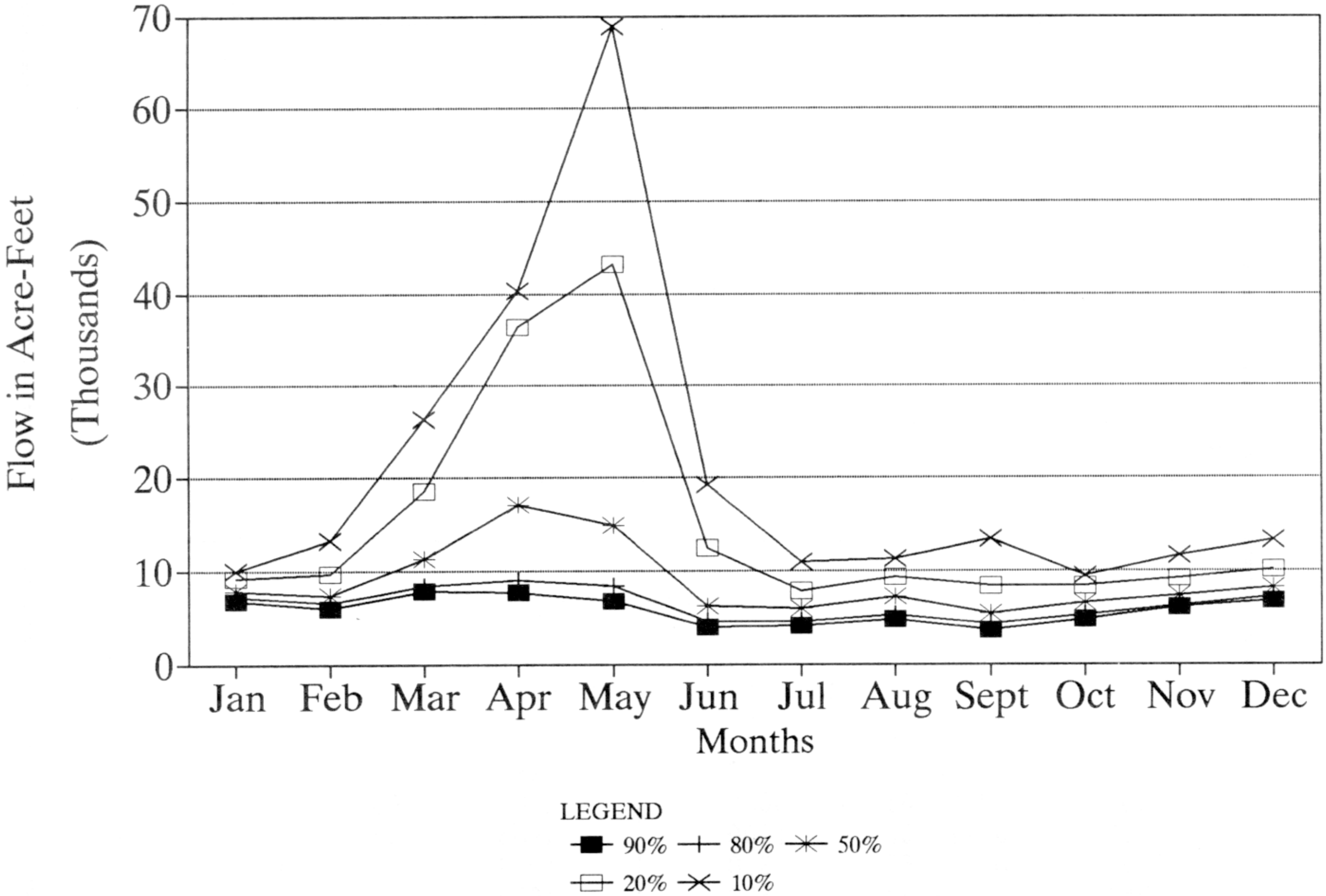


FIGURE 5-7
Monthly Streamflow Probabilities,
Kanab Creek Near Kanab

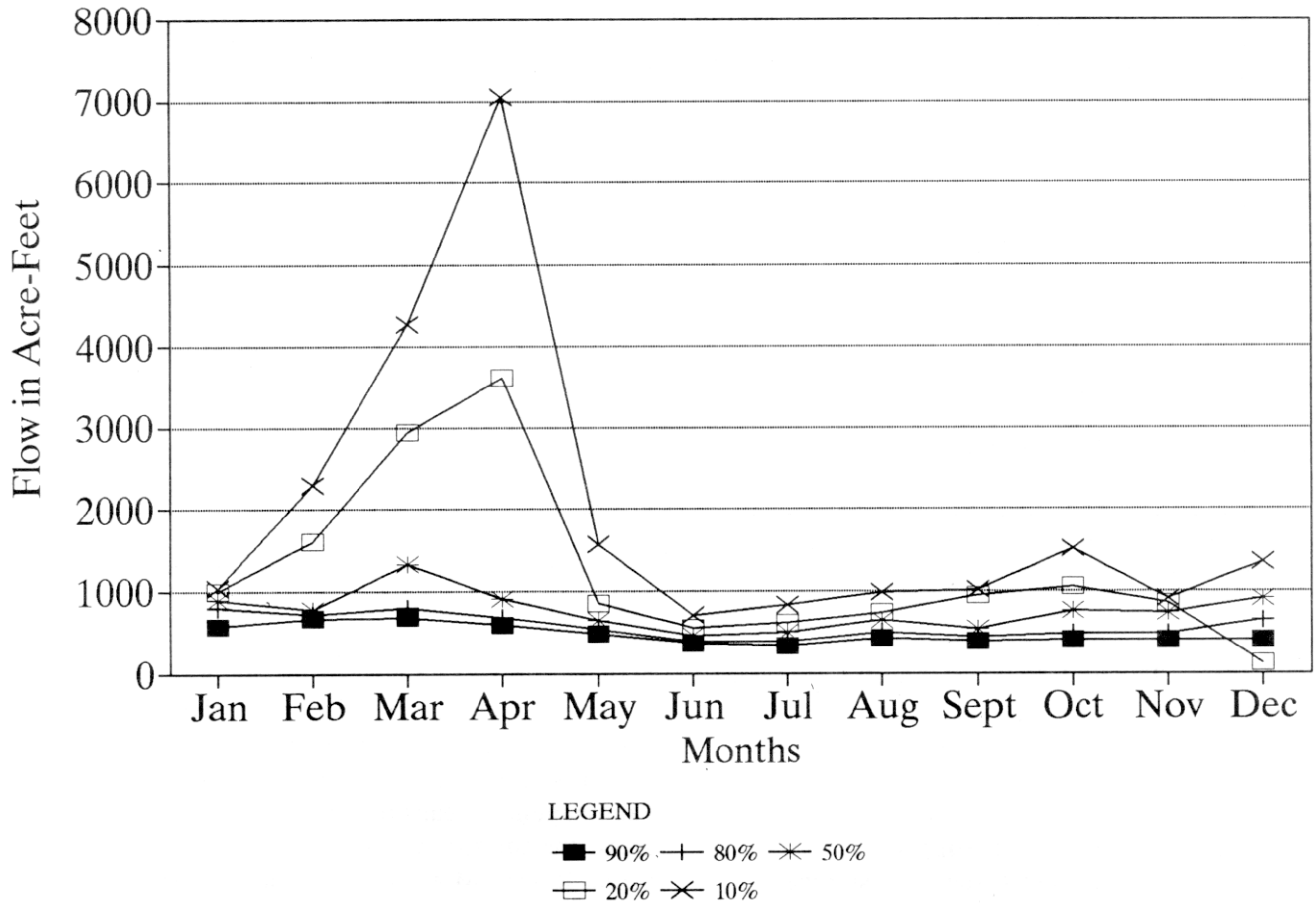


TABLE 5-7 FLOOD FREQUENCY FOR KANAB CREEK NEAR KANAB 1960-1968 AND 1979-1990		
Return Period	Probability[a]	Value (cfs)
2 Years	50	541.2
5 Years	20	1271.0
10 Years	10	1889.4
25 Years	4	2778.7
50 Years	2	3498.1
100 Years	1	4250.6
200 Years	0.5	5024.6
500 Years	0.2	6082.2

[a]Computed by Log Pearson Type III Distribution

1961. The peak flows on Kanab Creek and the dates of occurrence are shown in Table 5-6 with flood frequencies shown in Table 5-7.

5.3.2. Groundwater Supply

A groundwater system is a storage reservoir. The amount of water in storage depends on both recharge and discharge. On the average, groundwater discharge must be limited to recharge. Discharging more water than is recharged over a long time will deplete the amount in storage. This will cause well water levels to drop and some springs and wells will begin to dry up.

Most of the springs receive their supply from deep percolation of precipitation that falls on adjacent higher areas within the local watershed. Many springs in the cliffs close to the topographic divide between the northward flowing Sevier River drainage and southward flowing lower Colorado River drainage probably are fed in part by water that falls on the higher Markagunt and Paunsaugunt plateaus to the north. In these areas, the surface drainage is tributary to the Sevier River. Movement of groundwater from a higher surface drainage area to a lower surface drainage is a natural phenomenon that can occur wherever the water table is high enough to intersect the land surface.

In western Kane County, the water table is high under the Markagunt and Paunsaugunt plateaus because both areas receive good quantities of precipitation, and both are underlain largely by the jointed and water-receptive Claron formation. Here also much of the spring water in the south-facing cliffs is derived by groundwater capture from the natural surface drainage of the Sevier River to the north. A good example is Cascade Spring near Navajo Lake. The water supply to this spring comes from the topographic drainage of the Sevier River Basin. This source has been measured and is well documented.

Groundwater supplies come from unconsolidated and consolidated aquifers. Natural recharge to the groundwater in the Virgin River area and Kanab Creek is mostly by infiltration of precipitation as well as seepage from streams passing over recharge areas of the aquifer outcrops. Some recharge also occurs from subsurface inflow, mostly in areas east of the Hurricane Cliffs.

Withdrawal or discharge of groundwater is through wells used for public water supply, irrigation, domestic supply and stock watering. Besides this man-made discharge through wells, there is natural discharge through springs, drains, seepage into streams, evapotranspiration by plants and subsurface outflow from the basin. The long-term average annual groundwater discharge from the Virgin River is estimated to be the same as the average annual recharge value of 155,000 acre-feet.[3]

Groundwater discharge estimates for the central Virgin River basin have been made for two years.[5] These estimates are: 76,000 acre-feet, 1968; and 88,000 acre-feet, 1970. The average groundwater discharge for these two years is 82,000 acre-feet.

Estimated groundwater discharge for the upper Virgin River basin is 49,000 based on the year 1977.[4] Figure 5-8 shows the central and upper Virgin River, the Hurricane fault and the upper Kanab Creek and Johnson Wash area.

The discharge of groundwater for 1977 in the Kanab Creek and Johnson Wash drainages is estimated at 22,000 acre-feet annually.[4] About 5,000 acre-feet of this is subsurface outflow into Arizona.

Existing wells are good indicators of extent, location and amount of groundwater development. There are over 750 wells in the Kanab Creek/Virgin River Basin developed for various uses. Since most wells are developed as near as possible to the point of use, their location tends to indicate where groundwater is used. The exception is where some municipal wells are located at a distance from the actual place of use of the water. Most of the growth in irrigation well development occurred after 1950. See Section 19 for more discussion on groundwater.

5.4 Water Resouces Definitions

Many terms used in the water business have different meanings depending on the source, and are sometimes confusing. Some words are used interchangeably. A few commonly used water terms are defined for use in this document.

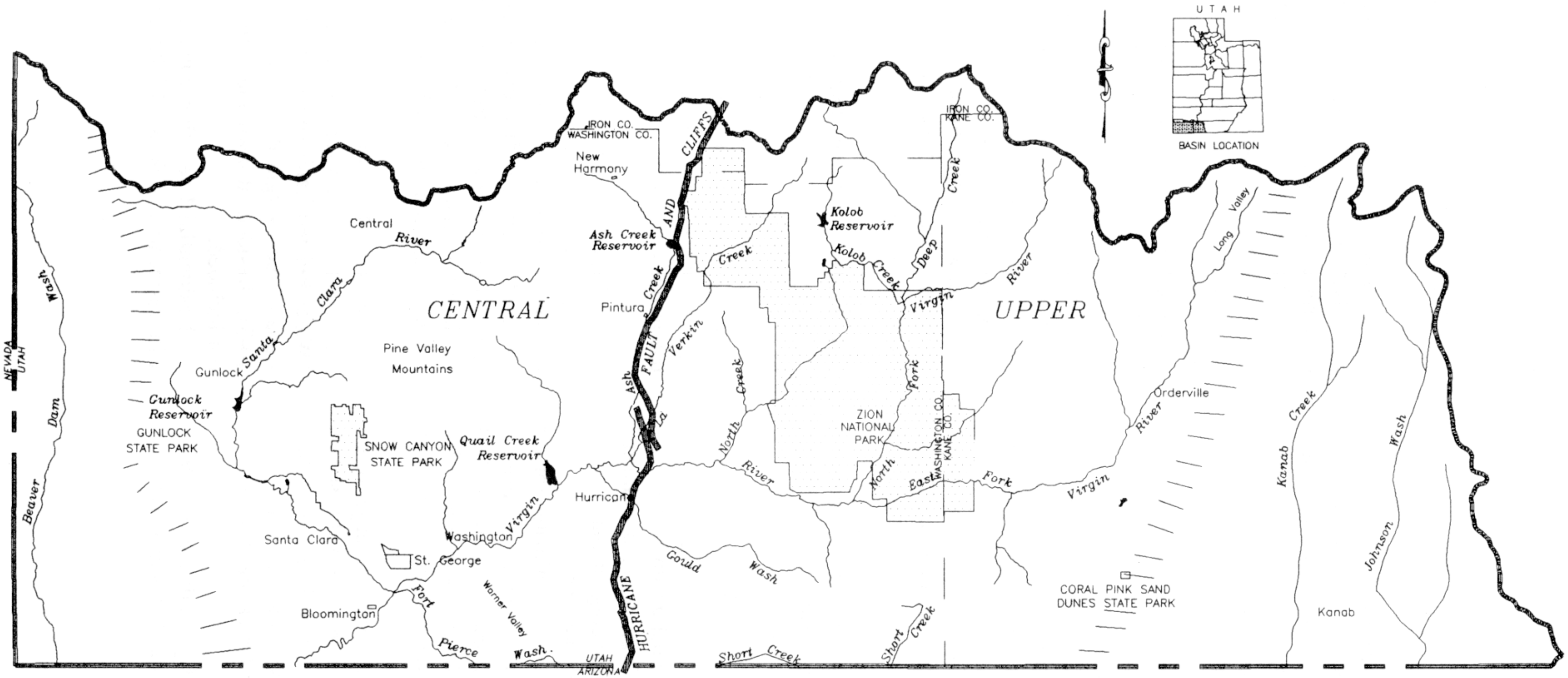
5.4.1 Water Use Terms

Water is used in a variety of ways and for many purposes. Water is often said to be "used" when it is diverted, withdrawn, depleted or consumed. But it is also "used" in place for such things as fish and wildlife habitat, recreation and hydropower production.

Cropland Irrigation Use - Water used for irrigation of cropland as identified in the "Water-Related Land Use Inventory of the Kanab Creek/Virgin River Basin" (see Table 10-3). Residential lawn and garden uses are not included.

Residential Use - Water use associated with residential cooking; drinking water;

FIGURE 5-8
Groundwater Study Area



Note: Hash marks indicate the groundwater areas discussed.
The Hurricane fault is the dividing line.

washing clothes; miscellaneous cleaning; personal grooming and sanitation; irrigation of lawns, gardens and landscapes and washing automobiles, driveways and other outside facilities.

Commercial Use - Uses normally associated with small business operations which may include drinking water, food preparation, personal sanitation, facility cleaning and maintenance and irrigation of facility landscapes.

Municipal Use - Uses normally associated with general operation of various public agencies and institutions including drinking water, personal sanitation, facility cleaning and maintenance and irrigation of parks, cemeteries, play grounds, recreational areas and other facilities. This term is commonly used to include residential, commercial and municipal uses.

Industrial Use - Use associated with the manufacturing or assembly of products which may include the same basic uses as commercial business. However, the volume of water used by industrial businesses can be considerably greater than water used by commercial businesses.

Municipal and Industrial (M&I) Use - This term is commonly used to include residential, commercial, municipal and industrial uses. It is sometimes used interchangeably with the term "public water use."

Private-Domestic Use - Includes water from private wells or springs for use in individual homes, usually in rural areas not accessible to public water supply systems.

Diversion - Water diverted from supply sources such as streams, lakes, reservoirs or groundwater for a variety of uses including cropland irrigation, residential, commercial, municipal and industrial. The terms diversion and withdrawal are often used interchangeably.

Withdrawal - Water withdrawn from supply sources such as lakes, streams, reservoirs or groundwater. This term is normally used in association with groundwater withdrawal.

Depletion - Water lost or made unavailable for return to a given designated area, river system or basin. It is intended to represent the net loss to a system. The terms consumption and depletion are often used interchangeably but are not the same. For example, water exported from a basin is a depletion to the basin system, but is not consumed in the basin. Therefore the exported water is available for use in another system.

Consumption - Water evaporated, transpired or irreversibly bound in either a physical, chemical or biological process.

Consumptive Use - Consumption of water brought about by human endeavors, i.e. use of water for residential, commercial, municipal, industrial, agricultural, power generation, recreation, fish and wildlife and other purposes along with the associated losses incidental to these uses.

5.4.2 Water Supply Terms

Water is supplied by a variety of systems for many users. Most water supply systems are owned by a municipality, but in some cases the owner/operator is a private company, or is a state or federal agency. Thus, a "public" water supply may be either publicly or privately owned. Also, systems may supply treated or untreated water.

Public Water Supply - Includes culinary water supplied by either privately or publicly owned community systems which serve at least 15 service connections or 25 individuals at least 60 days per year. Water from public supplies may be used for residential, commercial, municipal and industrial purposes, including irrigation of publicly and privately owned open areas.

Culinary Water Supply - Water meeting all applicable safe drinking water requirements for residential, commercial and municipal uses.

Municipal Water Supply - A supply that provides culinary water for residential, commercial, municipal and light industrial uses. The terms municipal, community and city are often used interchangeably.

Secondary Water Supply - Pressurized or open ditch water supply systems that supply untreated water for irrigation of privately and publicly owned lawns, gardens, parks, cemeteries, golf courses and other open areas. These systems, sometimes called "dual" water systems, are installed to provide a water supply in addition to the culinary supply.

5.4.3 Other Water Terms

Some water terms, peculiar to the water industry, are briefly defined in order to better understand the information presented.

Open Water Areas - Include lakes, ponds, reservoirs, streams and areas inundated or partially inundated adjacent to open water areas.

Carriage Water - Water needed for the hydraulic operation of a delivery system is referred to as carriage water.

Drinking Water - Water that is used or available for use as a culinary supply. The quality is typically the highest available in the locality.

Instream Flow - Water flow that is maintained in a stream for the purpose of preservation and propagation of fish.

Wetland and Riparian Areas - Land areas adjacent to rivers, streams, springs, bogs, lakes and ponds. These are ecosystems composed of plant and animal species highly dependent on water.

Export Water - Water leaving a river system or basin other than by the natural outflow in streams, rivers and groundwater.

5.5 Water Use

Water is used for municipal and industrial (M&I) use, agricultural purposes, wetlands and riparian areas, instream flows and for livestock watering. Agricultural water is primarily diverted from surface water sources. The majority comes from the Virgin and Santa Clara rivers. Groundwater is also used for irrigation, but to a much lesser degree than surface water. Water used for livestock watering facilities are generally small wells around ranches and in rangeland areas along with some surface water use.

Historically, groundwater has supplied most of the M&I water for a rapidly expanding population because treatment is usually not needed. In the past, about two-thirds of the groundwater came from wells and one-third from springs.

The diversion and use of water requires a water right (See Section 7.5, Water Rights Regulation). Water is also non-consumptively used for instream flows and power generation.

5.5.1 Municipal and Industrial Water Use

Municipal and industrial (M&I) water use, also called public use, refers to culinary quality supplies primarily used in homes, businesses and industry. It also includes culinary water used to irrigate lawns and gardens. Since a heavy industrial base does not exist in the basin, population is the main factor controlling the M&I water demand.

Surface water supplies are brought up to culinary standards in treatment plants. The town of Virgin has a small plant that treats North Creek water. During 1992, nearly 15.2 million gallons (46.6 acre-feet) were treated by this plant. The St. George water treatment plant, completed in 1989, treats Virgin River water. Over 976.8 million gallons (3,006 acre-feet) were treated in 1991. There is also a small treatment plant serving Springdale and Zion National Park. This plant is being updated to treat 14.1 million gallons (43.1 acre-feet) annually.

Daily water use per capita (GPCD) can vary substantially depending on how much culinary water is used to irrigate lawns and gardens, parks, golf courses and other outdoor facilities. Another factor in the basin municipal water use is the mobile tourist and part-time resident population. This use varies considerably on any given day, week or other time period.

Much of the basin is located where temperatures are generally 10°F to 15°F warmer than the rest of the state. Due in part to this fact, some areas of the basin have experienced rapid population growth as a recreation and retirement location during the last 15 to 20 years (Refer to Section 4, Demographics and Economic Future, for population data). The percentage of M&I water use compared to total use is expected to increase.

The per capita use for each city is calculated by using current annual public water supply diversions reported to the Utah Division of Water Rights, and dividing by 365. This gives the average water use in each city per day. This result is then divided by the 1990 census population to give daily use per capita. Each city's use is taken into account in calculating a basin average. The results are shown in Table 5-8.

For comparison, the average per capita use for the state is also shown. As can be seen, the per capita use is highly variable. Much of the variability between cities can be attributed to how much culinary water is used to irrigate lawns and gardens. This is partly because of the difference in lifestyles between rural agricultural areas such as Glendale and retirement communities such as St. George.

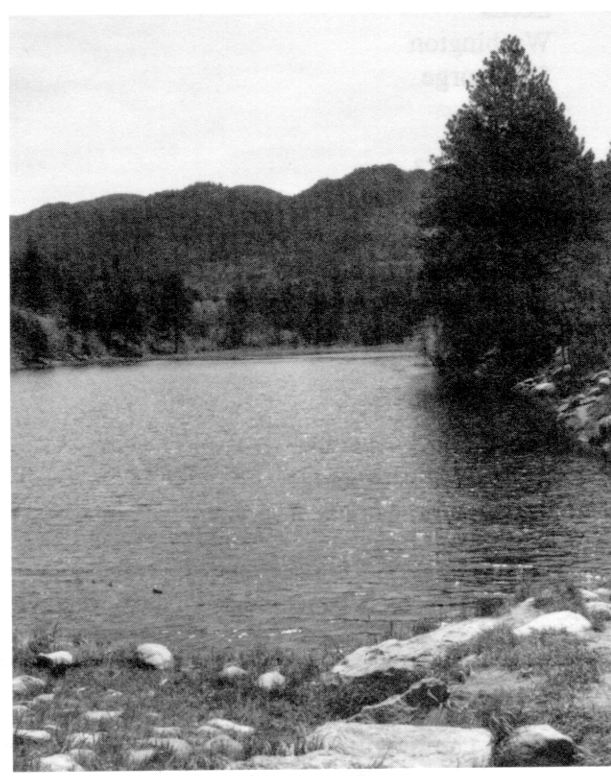


TABLE 5-8
CULINARY WATER DIVERTED PER CAPITA DAY

City	Population (1990)	Per Capita (gallons)
Alton	93	176
Kanab	3,289	359
Glendale	282	152
Orderville	422	211
Springdale	275	361
Rockville	182	199
Virgin	229	147
Kanarraville	228	337
New Harmony	101	381
Toquerville	488	158
La Verkin	1,771	245
Hurricane	3,915	366
Leeds	254	371
Washington	4,198	389
St. George	28,502	374
Ivins	1,630	197
Santa Clara	2,322	314
Hildale	1,325	153
Kane County Unicorp,	757	199
Washington County Unicorp.	2,209	364
Basin Average		347
State average		284
Iron County Average		337
Kane County Average		321
Washington County Average		350

Note: Does not include secondary (dual) systems.

Even in communities like St. George, water use varies at different times of the year. This is partly because of part-time residents and the fluctuating motel occupancy rate. Also, a mean annual July temperature variation of nearly 20°F. from the cooler to

TABLE 5-9 ESTIMATED CURRENT CULINARY WATER USE		
County	Diversions[a] (acre-feet)	Depletions (acre-feet)
Washington	18,570	9,660
Iron	90	50
Kane	1,670	870
Basin Total	20,330	10,580

[a]Includes only treated water use supplied by municipal systems.

hotter areas effects water use. Diversions and depletions for current culinary water use are summarized by county in Table 5-9. Diversions are from the Division of Water Rights Reports on public water suppliers.[19] Depletions are calculated as a percentage of the water diverted which does not return to the river system.

There are seven hydroelectric power plants in the basin. There is one near Gunlock, two near Veyo on the Santa Clara River and one each on La Verkin Creek and Cottonwood Creek. Two plants are part of the Quail Creek project (See Section 18).

5.5.2 Secondary Systems Water Use

Water from secondary systems (also called dual systems) is used in municipal areas to irrigate various landscapes such as lawns, gardens, parks, cemeteries and golf courses. The systems supply untreated water and may be owned and operated by municipalities, irrigation companies, special service districts and other entities. Most of the golf courses and many parks in the St. George area use water from secondary systems. Estimates of current diversions and depletions are summarized in Table 5-10.

5.5.3 Agricultural Water Use

The majority of the agricultural water is diverted from the Virgin and Santa Clara rivers, Kanab Creek, Johnson Wash and their tributaries. Groundwater is usually used as supplemental irrigation water and only makes up about 10 percent of the total agricultural diversions.

Surface irrigation water is obtained from direct flows in the rivers and streams and also from storage reservoirs. The areas with only direct flow rights often experience water shortages in the summer during times of low flows. Those areas where storage water is available are usually better off but also experience shortages in dry years.

Water quality effects the water requirements for agricultural crops. For data on water quality, refer to Sections 10 and 12.

Storage reservoirs make it possible to store water during high flows and have it available in times of low flows. Without storage reservoirs, this water would not be available for irrigation. Table 5-11 shows

TABLE 5-10
ESTIMATED CURRENT SECONDARY WATER USE

County	Diversions (acre-feet)	Depletions (acre-feet)
Washington	14,710	10,300
Iron	0	0
Kane	1,250	820
Basin Total	15,960	11,120

TABLE 5-11
EXISTING IRRIGATION WATER STORAGE RESERVOIRS[16]

Name	Stream	Location (S.	Tp.	R.)	Capacity (acre-feet)
Ash Creek	Ash Creek	7	39S	12W	3,175
Baker	Santa Clara	22	39S	16W	1,160
Gubler(Harris)	Reservoir Wash	4	38S	12W	31
Gunlock	Santa Clara	5	41S	17W	10,884
Ivins(offstream)	Santa Clara	36	41S	17W	475
Johnson Lake	Johnson Lake Canyon	5	43S	4½W	30
Kolob	Kolob Creek	36	38S	11W	5,586
McDonald Lake	E.F. Virgin	16	39S	6W	75
Quail Creek	Quail Creek[a]	36	41S	14W	40,325
South Creek	South Creek	9	42S	10W	1,580
Stratton	Virgin River (off-stream)	36	41S	14W	135
Total					64,027

[a]Primary inflow diverted from Virgin River.

the reservoirs with capacities greater than 30 acre-feet. The reservoirs in the table may also be used for other purposes. Quail Creek Reservoir, for example, provides municipal and industrial water for St. George, but also recreation as well as irrigation water.

Land use surveys were completed in the Kanab Creek/Virgin River Basin in 1991.[18] Most of the irrigated lands are near the Virgin River, North and East forks

overall wildlife diversity is associated with riparian areas, although this zone accounts for less than 5 percent of the total land mass. Typical riparian vegetation consists of

TABLE 5-12
ESTIMATED CURRENT IRRIGATION WATER USE[15]

County	Area[a] (acres)	Diversion (acre-feet)	Depletions (acre-feet)
Washington	16,680	87,800	39,320
Iron	1,520	7,860	1,490
Kane	7,400	27,640	10,490
Total	25,600	123,300	51,300

[a]Includes idle cropland

of the Virgin River, Santa Clara River, Kanab Creek and Johnson Wash. The areas of irrigated land, diversions and depletions are shown in Table 5-12. See Section 10 for more data.

Where records are available, water diverted is obtained from the Division of Water Rights or the irrigation companies. Diversion records are available for 13 of the 35 irrigation companies. A period of field monitoring would be required to obtain diversion data for those companies not keeping records.

5.5.4 Wetland and Riparian Water Use

Riparian areas are directly influenced by the availability of water. These areas include land and vegetation adjacent to rivers, streams, springs, bogs, wet meadows, lakes and ponds. Riparian areas display a great diversity of vegetation and wildlife species. In general, over 80 percent of the overall wildlife diversity is associated with riparian areas, although this zone accounts for less than five percent of the total land mass. Typical riparian vegetation consists of cottonwood trees, willows, salt cedar, arrowhead and seepwillow; grasslike plants such as rushes and sedges and aquatics such as watercress and cattails.

Good riparian habitat is important to support the fisheries and wildlife resources. The character and quality of the riparian zone will directly impact the fisheries resources in several ways. The riparian vegetation moderates the thermal input of the sun. The water temperature dictates species composition, population size and available nutrients. Riparian vegetation provides the majority of biomass input for an aquatic environment. For further information regarding wildlife, see Section 14.

The Virgin River, Santa Clara River and West Fork of the Beaver Dam Wash are all important habitat for migrating bald eagles, waterfowl and other raptors during the winter months. These areas are also important as year-long habitat for a wide variety of other wildlife species. The Virgin River from Shinob Kibe to La Verkin Springs and from the City of Virgin through Zion National Park are important for nesting and year-round peregrine falcon habitation. Riparian vegetation is found along the North and the East forks of the Virgin River, the Santa Clara River, Ft. Pierce Wash and the West Fork of Beaver Dam Wash as well as several smaller perennial streams. This provides habitat for amphibians and mammals.

5.5.5 Instream Flow Requirements

Instream flows are one form of use where water is not depleted. Water for instream flows is required in the reach of the Virgin River from the Quail Creek Reservoir diversion to the St. George and Washington Canal diversion for the protection of endangered species. This instream flow requirement is tied to the operation of Quail Creek Reservoir, and states that the lessor of either 86 cfs or the natural flow must be in the river during all months of the year. This was one of the requirements set forth by the U.S. Fish and Wildlife Service (USFWS) when the Quail Creek Project was built. The flow of 86 cfs is the water right for St. George and Washington Fields Canal Company at their diversion below Quail Creek Reservoir.

5.6 Interbasin Diversions

There is only one interbasin diversion of surface water in the basin. This is the diversion from the Santa Clara River (Grass Valley Creek) into Pinto Creek in the Cedar/Beaver River Basin (Stream gage 09408500). This diversion has historically averaged about 2,600 acre-feet annually. Groundwater inflow from the Sevier River Basin into the Kanab Creek/Virgin River Basin has been estimated at 16,500 acre-feet annually in a study of the water and related land resources of the Sevier River Basin.[11,12]

5.7 Water Quality

Streams in the Kanab Creek/Virgin River Basin flow from areas that are considerably different from each other in geology, land use, vegetation, altitude and climate. Water quality is measurably affected by these differences. Mineralized solutions are determined by rock and soil composition, climate, biological effects of plants and animals and water management and use as the water flows downstream.

Outcropping geologic formations affecting water quality include fine-grained clastic and carbonate rocks of Mesozoic age. Much of the water quality problems are the result of erosion. Natural erosion levels are high because of low vegetative densities, steep gradients and unstable substrates. Erosion contributes to increased salinity and to a higher concentration of trace elements.

The water quality problems are caused by point discharges as well as natural and non-point sources. The water quality in the mountain areas is good compared to the lower elevation stream reaches. Refer to Section 12, Water Pollution Control, for more detailed data. ■

5.8 References

1. Bingham Engineering. *Navajo Aquifer Investigation in Portions of Kane and Garfield Counties, Utah.* Alton Coal Project, Utah International, Inc., Salt Lake City, Utah, 1987.

2. Clyde, Calvin G. *Groundwater Development and Potential of the Beaver Dam Wash Aquifers.* Prepared for the City of St. George, 1990.

3. Ibid. *Groundwater Resources of the Virgin River Basin in Utah.* Utah Water Research Laboratory for the Utah Division of Water Resources, Logan, Utah, 1987.

4. Cordova, R.M. *Ground-Water Conditions in the Upper Virgin River and Kanab Creek Basin Area, Utah, with Emphasis on the Navajo Sandstone.* Technical Publication No. 70 prepared by the U.S. Geological Survey in cooperation with the Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1981.

5. Cordova, R.M., G.W. Sandberg, and Wilson McConkie. *Ground-Water Conditions in the Central Virgin River Basin, Utah.* Technical Publication No. 40, prepared by the U.S. Geological Survey in cooperation with the Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1972.

6. Goode, Harry D. *Reconnaissance of Water Resources of a Part of Western Kane County, Utah.* Utah Geological and Mineralogical Survey Water-Resources Bulletin 5, Salt lake City, Utah, 1964.

7. Ibid. *Second Reconnaissance of Water Resources in Western Kane County, Utah.* Utah Geological and Mineralogical Survey Water-Resources Bulletin 8, Salt Lake City, Utah, 1966.

8. Hardy, Thomas B., Brent Bartz, and Wendy Carter. *Population Dynamics of the Fishes in the Virgin River from 1984 through 1987 and Impact Analysis of the Quail Creek and North Creek Reservoir System.* Utah State University, Logan, Utah, 1989.

9. Leslie and Associates. *Hydrological Study of Beaver Dam Wash Aquifers in Mohave County, Arizona.* Cedar City, Utah, 1990.

10. U. S. Department of Agriculture in cooperation with the Utah Department of Natural Resources and U.S. Department of Interior. *Water and Related Land Resources, Beaver River Basin, Utah-Nevada.* Salt Lake City, Utah, 1973.

11. U. S. Department of Agriculture in cooperation with the Utah Department of Natural Resources. *Water and Related Land Resources, Sevier River Basin, Utah.* Salt Lake City, Utah, 1969.

12. Ibid. *Water Supply - Sevier River Basin, Utah.* Appendix II. Salt Lake City, Utah, 1991.

13. U. S. Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin - Utah Cooperative Study.* Salt Lake City, Utah, 1990.

14. Utah Division of Water Resources. *A Water-Related Land Use Inventory Report of the Virgin River Area.* Salt Lake City, Utah, 1990.

15. Ibid. *Hydrologic Inventory of the Virgin and Kanab Study Units.* Salt Lake City, Utah, 1983.

16. Ibid. *Inventory of Reservoirs and Potential Damsites in the Virgin River Basin.* Salt Lake City, Utah, 1988.

17. Ibid. *Municipal and Industrial Water Diversion and Depletion for the Virgin River and Kanab Creek Drainage Basins.* Salt Lake City, Utah, (In preparation).

18. Ibid. *Water Related Land Use Inventory of the Kanab Creek/Virgin River Basin.* Salt Lake City, Utah, 1993.

19. Utah Division of Water Rights. *Water Use Data for Public Water Suppliers and Self-Supplied Industry in Utah.* Reports 1-8, 1960-89 and 1990-91 (unpublished). Salt Lake City, Utah.

20. Utah Energy Office. *A Survey of Small Hydroelectric Potential at Existing Sites in Utah.* Salt Lake City, Utah, 1980.